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# Comparison of Natural Regeneration Density and Diversity in Beech-Hornbeem Type in Relation to Physiographic Conditions

**[1]Meysam Mojarabi, [1]Abbasali Nowbakht, [2]Seyed Nasseredin Emadi, [2]Mehran Moafi, [2]Korosh Sharifi**

*[1]Department of Forestry, Faculty of Natural Resource, University of Mazandarn, Iran.*
*[2]Department of Forestry, Faculty of Natural Resource, University of Olom and Tahghighat Tehran, Iran*

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**ABSTRACT**

*Surveying the biodiversity and maintaining it is of the most important factors of achieving permanent development. Therefore surveying the influence of physiographic conditions on density and diversity of regeneration of woody species is very important. For this purpose, 160 sample plots with the Systematic-Random method, in 400 $m^2$ were surveyed in Gardeshi, Chachkam and Khalkheil districts of forest management plans of Mazandaran Wood and Paper Industries. In each sample plot the number of natural regeneration was 12.5$^{cm}$ DBH and smaller than that was counted according to the distinction of the species. In this sample plots the slop percentage, aspect and altitude were also recorded. Heterogeneity indices consist of simpson, reciprocal of simpson, shannon and evenness indices including camargo, simpson and smith-wilson were used. After studying the data, 12 woody species were distinguished. Analysis of variance of the regeneration density in slope, aspect and altitude categories showed significant differences at the level of 99% in different categories, so that the most regeneration density was 20-40% slope, north-west aspect and 900-1000 altitude in categories and the least was 0-20% slope, south-east aspect and 1100-1200 altitude. Also Analysis of variance of biodiversity indices between altitude categories, showed significant differences at the level of 99%. But for biodiversity indices, there was not significant differences in slope and aspect categories.*

**Keyword:** Regeneration, Diversity, Slope, Aspect, Altitude

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## INTRODUCTION

With ever increasing population of the world and science and technology advance, the pressure of human' destruction on the nature has increased and the face of the nature is loosing its natural and initial form day after the day [10]. The main purpose in natural resources management is biodiversity maintenance in natural ecosystems [29]. Assessing biodiversity and the spatial structures of forest ecosystems are important for forestry and nature conservation [31]. Biodiversity maintenance is a universal concern which needs the implementation of stable management methods in local measure domain. Forest ecosystem are not exception in this respect and in IUFRO conference, it is mentioned to the subject of biodiversity and stable management of the forest [22]. In fact, maintaining the basic and initial structure of the forest is an important feature in forest ecosystem management. So that structural features of natural heaps (groups) and biodiversity maintenance at these heaps, will be used in

determining ecological shelter (home) of the species, testing heterogeny and temporal dynamics of vegetations, measuring life renewal models and dynamics of the holes, expressing the diversity of microclimate and predicting wood production [32]. From the most important factors which influence diversity, we can mention to physiographical ones [18]. Hyrcanian forest ecosystem is considered to be one of the last remnants of natural deciduous forests in the world. In comparison to European broad-leaved forests, the hyrcanian forests seem to have remained from the Tertiary and to be relic ecosystem [12]. has properly showed that interior changes of the heap are related to topography, succession and the intensity of human interference. The forest of Iran, especially industrial forest of the northern part which their wood productivity role is significant among other forest is influenced by harmful activities of human. Here, topography has the most direct and indirect effect on plant cover [33]. Studying the effect of heap and topography parameters on species diversity of tree in a natural mixed forest in Turkey showed that there is no significant relation between species diversity and heap, slope and altitude parameters, but for the aspect there was a significant correlation [27]. In comparison, between regeneration density and diversity of wood species in relation with physiographical situations of south-side of Caspian Sea, concluded that the most regeneration density was seen in 80-100% slope and the least one was seen in 20-40% slope. The analysis of variances related to altitude and aspect categories didn't show significant difference in generation density, used diversity indices and different physiological categories [20]. In study to analyze biodiversity of woody species in oak bushes in Strait of Gibraltar and concluded that in the south side, richness of species and the number of local species are loss, and in the north side of the strait, dispersion of the species are more. Finally, they expressed incorrect management in the related zone and intensive pressure from grazing the ranch as the reason of difference in biodiversity [26]. In the analysis of natural generation of oak species in Canada, concluded that opening of the heap and shining light to the surface of the forest causes increase of renewal of the species [23].

The purpose of this research is to compare the natural regeneration density and diversity in relation to physiological condition of Beech-Hornbeem type. This plant population has involved a significant surface of the northern forest and study of biodiversity and evaluation of its generation situation plays an important role in better management of these heaps.

## MATERIALS AND METHODS

### ANALYSIS METHOD

Studied Zone:

This research was done in Gardeshi, Chachkam and Khalkhil districts of forest management located in south part of Sary. The forest of this area is located between 52° 50` to 53° 37` of east longitude and 36° 00` to 36° 27` of north longitude. According to Amberjhe climate viewer, Climatology studies showed that the climate of this zone is located in cold and wet part. The most amount of raining is 1094 mm and the least is 439 mm. Generally, the soil of the studied zone has the root of limy and Marny and in some parts, it is sandy lime and the soil has a tissue which is a little heavy.

These forests have fageto-carpinetum forest succession and other species such as Maple, Cappadocian Maple, Siberian Elm, Wych Elm, Lim-Tree, Caucasian Walnut, Oak, Alder, wild cherry and Date-Plum [1,2].

### Study Method

This study was done in a surface of about 500 hectares and in 700-1200 altitude of south forest of Sary. Sampling was done through systematic-random method with a network of 200*150 meter and in general, 160 sample plots with 400 Sq. meters in area were implemented on the ground [4,19]. In each sample plot, the number of natural regeneration was 12.5 cm DBH and smaller than that was measured according to the distinction of the species. In theses sample plots, the slope percentage was recorded with the help of Sonto slope meter, the altitude was recorded with the use of Altimeter and different aspects were recorded, too. In relation to the current situations, the zone slope was divided into three classes (0-20%, 20-40%, 40-60%) and altitude categories were divided into five classes (700-800, 800-900, 900-1000, 1000-1100, and 1100-1200 meters). After gathering considered factors in the surface of sample plot, all data were recorded in SPSS 16 statistical software.

### Data Analysis

To analyze regeneration density data in different categories of slope, aspect and altitude, we used one-side analysis of variance by using F-test and Tooki's multiple measurements. The number of regeneration of each species at this

research was used as a variable in the formula of heterogeny and evenness. For this purpose, heterogeny indices such as simpson. Reciprocal of Simpson and Shannon-winner and evenness indices including Camargo, Simpson and Smith-Wilson (table 1) were calculated from official software of Ecological Methodology ver. 6 and the amount obtained from these indices were analyzed in SPSS 16 software with F-test.

**Table 1- Equations of evenness and unevenness index (Krebz, 1998 )**

| Equations | Parameters | Index name | Index |
|---|---|---|---|
| $1-D=1-\sum(p_i)^2$ | $1-D$ = Simpson index of diversity<br>$p_i$ = *Proportion of the species i* in community | Simpson | Unevenness |
| $\frac{1}{D}=\frac{1}{\sum p_i^2}$ | $\frac{1}{D}$ = Simpson reciprocal diversity index<br>$p_i$ = Proportion of species *i* in the community | Simpson reciprocal diversity index Hill ) (index | |
| $H'=\sum_{i=1}^{s}(P_i)(Log_2^{Pi})$ | $P_i$ = Proportion of species *i* To total sample<br>$S$ = Number of pecies | Shannon-wiener | |
| $E=1..0-\left[\sum_{i=1}^{s}\sum_{j=i+1}^{s}\left[\lvert P_i-Pj\rvert/S\right]\right]$ | $E$ = Camargo index of evenness<br>$P_i$ = Proportion of species in *i* total sample<br>$Pj$ = Proportion of species *j* in total sample<br>$S$ = number of species in total sample | Camargo | |
| $(E1/D)=\frac{1/D}{S}$ | $(E\,1/D)$ = Simpson evenness criteria<br>$D$ = Simpson index of diversity<br>$S$ = Number of species in sample | Simpson | Evenness |
| $E_{Var}=1-\left[\frac{2}{\pi}\right]\left[\arctan\left\{\frac{\sum_{i=1}^{s}\left[Log\sum_{e}^{(ni)}-\sum_{j=1}^{s}Log_e^{(nj)/S}\right]^2}{S}\right\}\right]$ | $E_{Var}$ = Smith and Wilson index<br>*ni* = Number of individuals *i* in sample<br>*nj* = Number of individuals *j* in sample | Smith and Wilson | |

## RESULTS

The diversity of regeneration related to tree species was analyzed in different categories such as slope, aspect and altitude. Results showed new life for 12 wood species (table 10). For determining significance level, variance analysis was considered in different physiologic categories in relation to regeneration density. Variance analysis for different slope categories showed significant difference at the level of 99% among different categories (table 2 & 3). So that the most regenerating density was seen in 20-40% slope category and the least one was seen in 0-20% slope category (Fig. 1).

**Table 2- Analysis of variance of regeneration density in different slope gradients, slope directions and elevation at sea level**

| Variable | Degree of freedom | F value | Significant |
|---|---|---|---|
| Slope gradient | 2 | 39.644 | 0.001** |
| Slope direction | 6 | 5.266 | 0.001** |
| Elevation at sea level | 4 | 14.629 | 0.001** |

**Table 3- The mean ± standard error of regeneration density and diversity in slope classes**

| Slope classes | Regeneration density | Unevenness indices | | | Evenness indices | | |
|---|---|---|---|---|---|---|---|
| | | Simpson | Reciprocal Simpson | Shannon-wiener | Camargo | Smith and Wilson | Simpson |
| 0-20 | 11.7±0.568 | 0.282±0.043 | 1.212±0.16 | 0.625±0.098 | 0.472±0.061 | 0.449±0.069 | 0.493±0.065[b] |
| 20-40 | 135.647±25.844 | 0.377±0.026 | 1.624±0.108 | 0.794±0.057 | 0.565±0.033 | 0.563±0.037 | 0.593±0.036[a] |
| 40-60 | 111.862±16.859 | 0.326±0.056 | 1.3±0.213 | 0.724±0.124 | 0.442±0.072 | 0.438±0.077 | 0.423±0.075[a] |

*Means with different letter shows significant difference at probability level of 1%, ns: is not significant.*

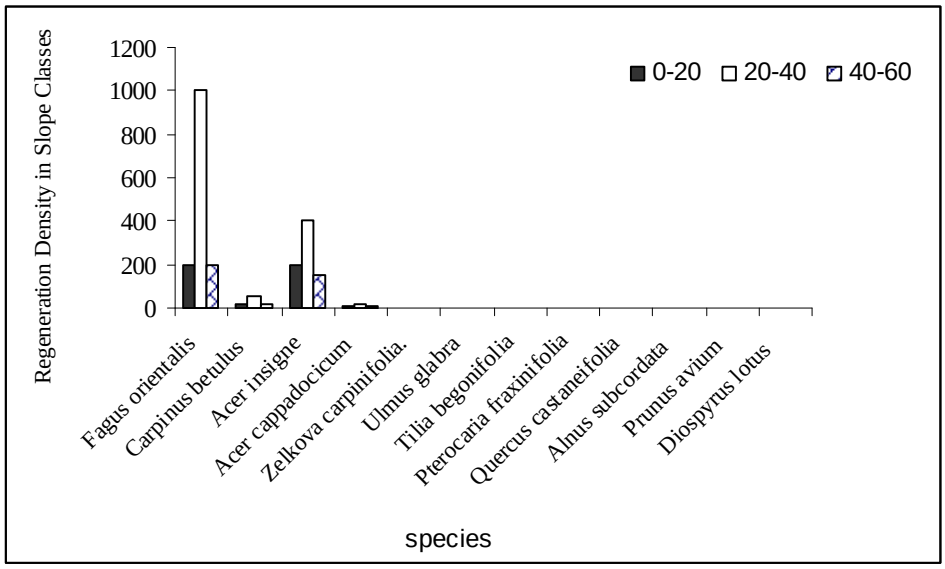


**Fig. 1- Regenerating density of wood species in different slope categories.**

Variance analysis for different categories of altitude showed significant difference at the level of 99% between different categories (table 2 & 4). So that the most regenerating density was seen in 900-1000 m altitude and the least one was seen at 1100-1200 m altitude.

**Table 4 - The mean ± standard error of regeneration density and diversity in elevation classes**

| Elevation classes | Regeneration density | Unevenness indices | | | Evenness indices | | |
|---|---|---|---|---|---|---|---|
| | | Simpson | Reciprocal Simpson | Shannon-wiener | Camargo | Smith and Wilson | Simpson |
| 700-800 | 116.741±15.868[a] | 0.415±0.048[a] | 1.735±0.188[a] | 0.945±0.112[a] | 0.595±0.053[a] | 0.602±0.062[a] | 0.625±0.058[a] |
| 800-900 | 134.566±17.372[a] | 0.385±0.036[a] | 1.633±0.136[a] | 0.866±0.082[a] | 0/583±0.046[a] | 0.574±0.053[a] | 0.611±0.049[a] |
| 900-1000 | 159.273±27.321[a] | 0.351±0.04[a] | 1.486±0.16[a] | 0.814±0.094[a] | 0.517±0.051[a] | 0.494±0.054[a] | 0.544±0.054[a] |
| 1000-1100 | 129±14.561[a] | 0.291±0.064[a] | 1.385±0.268[a] | 0.693±0.157[a] | 0.505±0.081[a] | 0.485±0.091[a] | 0.525±0.087[a] |
| 1100-1200 | 64.561±7.622 | 0[b] | 0[b] | 0[b] | 0[b] | 0b | 0[b] |

*Means with different letter shows significant difference at probability level of 1%, ns: is not significant.*

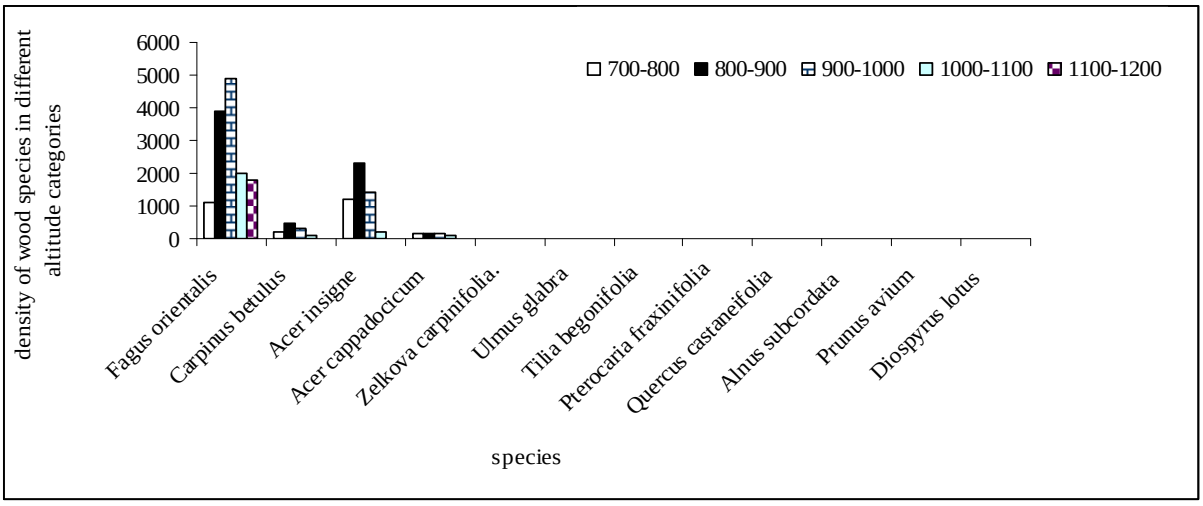


**Fig. 2: Regenerating density of wood species in different altitude categories.**

Variance analysis of regenerating density in different aspects showed significant difference in 99% level (table 2 & 5). So that the most regenerating density was seen in northern west aspect and the least one was seen at southern east aspect.

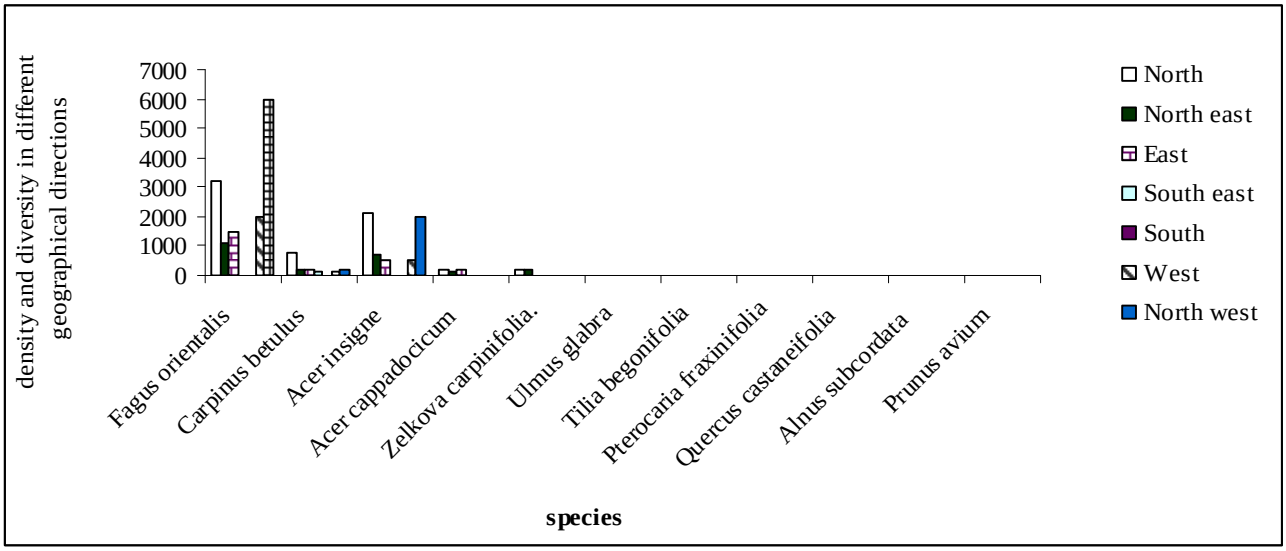


**Fig. 3: Regenerating density for wood species in different aspects.**

**Table 5-The mean ± standard error of regeneration density and diversity in different geographical directions**

| Slope direction | Regeneration density | Unevenness indices | | | Evenness indices | | |
|---|---|---|---|---|---|---|---|
| | | Simpson | Reciprocal Simpson | Shannon-wiener | Camargo | Smith and Wilson | Simpson |
| North | 152.174±14.049ab | 0.398±0.038 | 1.714±0.149 | 0.874±0.086 | 0.568±0.044 | 0.562±0.051 | 0.593±0.048 |
| North east | 101.6±15.629ab | 0.338±0.049 | 1.384±0.183 | 0.728±0.107 | 0.542±0.068 | 0.545±0.076 | 0.572±0.073 |
| East | 84.774±11.628ab | 0.321±0.053 | 1.383±0.22 | 0.741±0.124 | 0.466±0.067 | 0.471±0.073 | 0.489±0.071 |
| South east | 20±6.928b | 0.226±0.226 | 0.821±0.821 | 0.469±0.469 | 0.25±0.25 | 0.261±0.261 | 0.274±0.274 |
| South | 44±24.331ab | 0.289±0.161 | 1.141±0.594 | 0.561±0.295 | 0.561±0.295 | 0.557±0.294 | 0.571±0.297 |
| West | 158±26.753ab | 0.29±0.068 | 1.201±0.256 | 0.652±0.147 | 0.425±0.086 | 0.429±0.093 | 0.456±0.094 |
| North west | 269.454±50.456a | 0.328±0.043 | 1.39±0.164 | 0.726±0.095 | 0.525±0.062 | 0.497±0.07 | 0.548±0.065 |

*Means with different letter shows significant difference at probability level of 1%, ns: is not significant.*

**Diversity in aspects:**
Also, to analyze wood species diversity, we used different heterogeny and evenness indices. The amounts of these indices were examined in different categories of slope, aspect and altitude.

The implemented variance analysis among these indices and different physiographic categories showed that heterogeny indices (Simpson, reciprocal of Simpson and Shannon -Wiener) and evenness indices (Kamargo, Smith-Wilson and Simpson) have no significant difference at slope and different aspect categories (table 3-5-7-8).

**Table 6- The value of evenness and unevenness indices in different elevation classes, slope classes and geographical directions**

| Variables | Classes | Unevenness indices | | | Evenness indices | | |
|---|---|---|---|---|---|---|---|
| | | Simpson | Reciprocal Simpson | Shannon-wiener | Camargo | Smith and Wilson | Simpson |
| Slope gradient | 0-20 | 0.281 | 1.211 | 0.625 | 0.472 | 0.449 | 0.492 |
| | 20-40 | 0.377 | 1.624 | 0.793 | 0.564 | 0.563 | 0.593 |
| | 40-60 | 0.325 | 1.300 | 0.723 | 0.442 | 0.437 | 0.423 |
| Slope direction | North | 0.397 | 1.714 | 0.874 | 0.567 | 0.561 | 0.593 |
| | North east | 0.337 | 1.380 | 0.728 | 0.542 | 0.545 | 0.571 |
| | East | 0.320 | 1.380 | 0.74 | 0.46 | 0.471 | 0.482 |
| | South east | 0.228 | 0.820 | 0.468 | 0.25 | 0.260 | 0.273 |
| | South | 0.432 | 1.712 | 0.842 | 0.841 | 0.836 | 0.856 |
| | West | 0.289 | 1.20 | 0.652 | 0.425 | 0.428 | 0.456 |
| | North west | 0.327 | 1.389 | 0.725 | 0.525 | 0.497 | 0.548 |
| Elevation at sea level | 700-800 | 0.415 | 1.734 | 0.945 | 0.594 | 0.601 | 0.624 |
| | 800-900 | 0.384 | 1.632 | 0.866 | 0.582 | 0.573 | 0.611 |
| | 900-1000 | 0.351 | 1.486 | 0.814 | 0.505 | 0.485 | 0.525 |
| | 1000-1100 | 0.291 | 1.385 | 0.692 | 0.516 | 0.494 | 0.543 |
| | 1100-1200 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 7- Analysis of variance for the evenness and unevenness indices of regeneration in slope classes**

| Index | df | F value | Significant |
|---|---|---|---|
| Simpson | 2 | 1.750 | 0.177 $^{ns}$ |
| Reciprocal Simpson | 2 | 2.626 | 0.088 $^{ns}$ |
| Shannon-wiener | 2 | 1.100 | 0.335 $^{ns}$ |
| Camargo | 2 | 1.852 | 0.160 $^{ns}$ |
| Smith and Wilson | 2 | 1.845 | 0.162 $^{ns}$ |
| Simpson | 2 | 2.719 | 0.069 $^{ns}$ |

*ns: is not significant.*

**Table 8- Analysis of variance for the evenness and unevenness indices of regeneration in different geographical directions**

| Index | df | F value | Significant |
|---|---|---|---|
| Simpson | 6 | 0.608 | 0.723$^{ns}$ |
| Reciprocal Simpson | 6 | 0.937 | 0.470 $^{ns}$ |
| Shannon-wiener | 6 | 0.580 | 0.746 $^{ns}$ |
| Camargo | 6 | 0.806 | 0.566 $^{ns}$ |
| Smith and Wilson | 6 | 0.577 | 0.748 $^{ns}$ |
| Simpson | 6 | 0.699 | 0.651 $^{ns}$ |

*ns: is not significant.*

**Table 9- Analysis of variance for the evenness and unevenness indices of regeneration in different elevation at sea level**

| Index | df | F value | Significant |
|---|---|---|---|
| Simpson | 4 | 6.387 | 0.000$^{**}$ |
| Reciprocal Simpson | 4 | 7.221 | 0.000$^{**}$ |
| Shannon-wiener | 4 | 6.032 | 0.000$^{**}$ |
| Camargo | 4 | 8.804 | 0.000$^{**}$ |
| Smith and Wilson | 4 | 6.932 | 0.000$^{**}$ |
| Simpson | 4 | 8.532 | 0.000$^{**}$ |

*** significant at probability level of 1%.*

But implemented variance analysis among these indices and altitude categories shows significant difference in 99% assurance level (table 9). So that the amount of these indices with altitudes about 1100-1200m are different from other altitude classes.

**Table 10- List of natural regeneration in study area**

| no | Scientific name | Family |
|---|---|---|
| 1 | *Fagus orientalis* Lipsky | *Fagaceae* |
| 2 | *Carpinus betulus* L. | *Betulaceae* |
| 3 | *Alnus subcordata* C. A. M. | *Betulaceae* |
| 4 | *Acer insigne* B. | *Aceraceae* |
| 5 | *Acer cappadocicum* GLED. | *Aceraceae* |
| 6 | *Tilia begonifolia* STEV. | *Tiliaceae* |
| 7 | *Zelkova carpinifolia* Dipp. | *Ulmaceae* |
| 8 | *Ulmus glabra* H. | *Ulmaceae* |
| 9 | *Quercus castaneifolia* C. A. M. | *Fagaceae* |
| 10 | *Prunus avium* L. | *Rosaceae* |
| 11 | *Pterocaria fraxinifolia* (L.) | *Juglandaceae* |
| 12 | *Diospyrus lotus* L. | *Ebenaceae* |

## DISCUSSION

The forest of northern part of Iran are one of the most precious and unique forest in the world. Diversity in physiographic structures of these woodlands and their expansion indifferent conditions have caused to creation of a diverse structure. So that, the regenerating density and diversity of plant species of these woodlands is so influenced by environmental factors. Hence, physiographic factors are counted as effective factors on dominance and diversity of trees, renewal of the life and continuity of the product in forest ecosystems [28]. At this research, factors such as slope, altitude and different aspects has significant effect on regeneration density among different categories. At this research, because fageto was the dominant species and preferred sunshade, it's most regenerating amount was seen in north-west part which had less sunlight. Altitude changes in the above said zone showed that if the altitude increases (more than 1000 meters), the most amount of regenerating is for fageto. So that, it created reduction in density, richness and evenness. The reason of this event is high competetive power of fagete specieswith the other species in high altitudes of these woodlands. These results are consistent with the findings of some researchers [6,7,13,15,30].

Some studies showed that with increase in altitude, the plant diversity is reduced but their frequency is increased [3,8,11,14,24,25]. So that, the most diversity and richness was seen at 800-1000 m of altitude, and also showed that the evenness amount in high altitudes is more, because the harsh climate will cause to dominance of some species[5,17]. In low altitudes, temperature increase will cause the increase of diversity and richness[9] These matters are consistent with the results of this research.

Like many other forest zones in northern part of Iran, the studied zone of this research was destroyed before by villagers who were living at the forest-side, and the presence of livestock in these fields had caused many tensions. Because the fields which has a slope less than 20% were easier to access for human and livestock trafficking, and because south and southeast aspects were more exposed to sunlight and had more provender, were more exposed to change and destruction. So that, soil grounding and foraging at these fields has made an inappropriate ground for natural regenerating. Some studies which were related to these findings showed that the most regenerating density is at slope class of 20-40% and in slopes less than 20%, because of easy access to forest and presence of wandering livestock, and easier traffic in low slopes, natural regenerating density and diversity is increased a lot. Also, because of cutting the trees and bringing them out of the forest and aggression of villagers who lived at forest-side, illegal and unmethodical explanation in theses zones had an additional impact on reduction of seeding amount [8,16,17,18,20].

In relation with this fact that Beech-Hornbeem forest type is one of the most important successions in northern forest of Iran and fageto species is the most industrial species of these woodlands. To achieve the goals of silvics which is near to the nature, we should do something to reduce h tension which is made at these fields. We can do this with exact protects of these woodlands and bring livestock out of them. Also, to make faster the process of forest

regeneration, executing exact notation according to silvics criteria which is near to the nature and enriching the field through planting some trees. Planting seeds and making scratch on the surface (of the soil) has a high importance.

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